NOAA-EPA's New National Air Quality Forecasting Capability:

Initial Steps

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Outline

- **Background and Current Capability**
- **Path Forward: Transitioning capabilities to operations**
- **Progress toward expanded capabilities**

National Air Quality Forecasting

Background: Timing and Partners

Science Maturing

- **Ozone forecast models demonstrated in lab -- others in development**
- **Other nations (e.g. Canada, Australia) have AQ forecast capability**

NOAA-EPA Agreements

- **DOC Deputy Secretary and EPA Administrator signed MOU/MOA for AQ forecasting May 6, 2003**

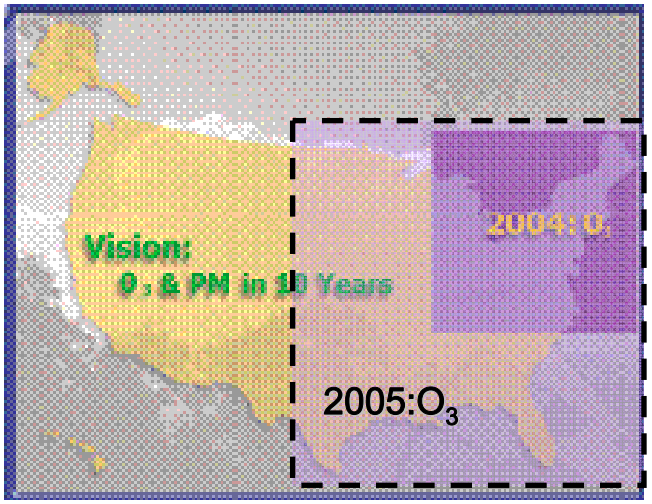
Congressional Interest

- **H.R. 4 Energy Policy Act of 2002 (Senate Amendment); Directed appropriations**

Constituent Interest

- **AQ managers, public health officials, private weather sector partners urge NOAA to provide AQ forecasts**

National Air Quality Forecast Capability:
Phased Growth



Current: 1-day forecast guidance for ozone

- **Developed and deployed initially for Northeastern US, September 2004**
- **Expanded over Eastern US, Aug 2005**

Near-Term

- **Convert driving met model from Eta to WRF: Spring 2006**
- **Experimental test of ozone guidance over CONUS: Summer 2006**
- **Deploy Nationwide by 2009**

Longer range (within 10 years):

- **Develop and test capability to forecast particulate matter concentration**
  - ***Particulate size ≤ 2.5 microns***
- **Data assimilation for air quality**
- **Extend air quality forecast range to 48-72 hours**
- **Include broader range of significant pollutants**

National Air Quality Forecast Capability
Initial Operational Capability (IOC)

Model Components: Linked numerical prediction system

Operationally integrated on NCEP's supercomputer

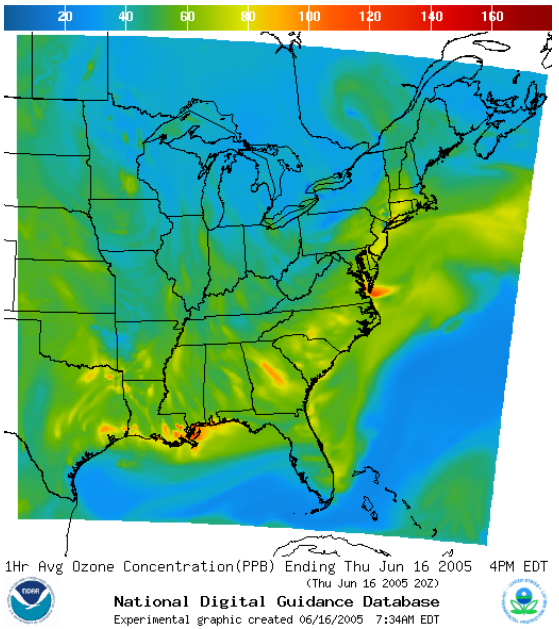
- ***NCEP mesoscale NWP: Eta-12***
- ***NOAA/EPA community model for AQ: CMAQ***

Observational Input:

- ***NWS weather observations***
- ***EPA emissions inventory***

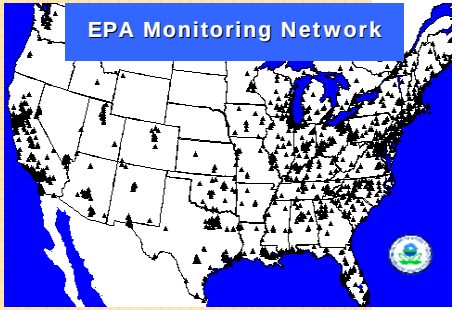
Gridded forecast guidance products

Delivered to NWS Telecommunications Gateway and EPA for users to pull 2x daily



Verification basis

EPA ground-level ozone observations

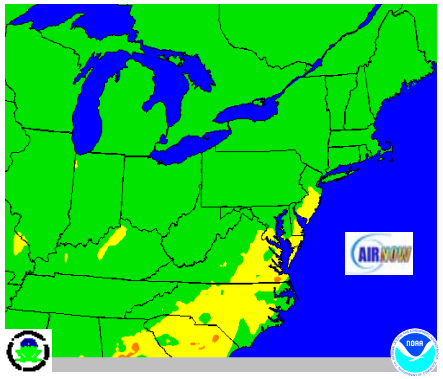


Customer outreach/feedback

NCEP mesoscale NWP: Eta-12

State & Local AQ forecasters coordinated with EPA

Public and Private Sector AQ constituents



AQI: Peak Jul 28

National Air Quality Forecast Capability

Major Model Components in IOC

NWP Model

NAM / Eta-12

NOAA / NWS

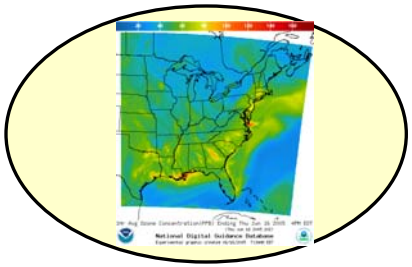
Weather Observations

NWP Post-processors for AQ Modules

AQ Module:
Emissions Preprocessor
PREMAQ
NOAA / OAR and EPA / ORD

EPA's National Emissions Inventory:
EPA / OAQPS

AQ Module:
Air Quality Reactive Transport
CMAQ
NOAA / OAR and EPA / ORD



IT / Comms
NOAA / NWS
and
EPA / OAQPS

Transition to Operations
Testing Phases

Research

Does the science work?

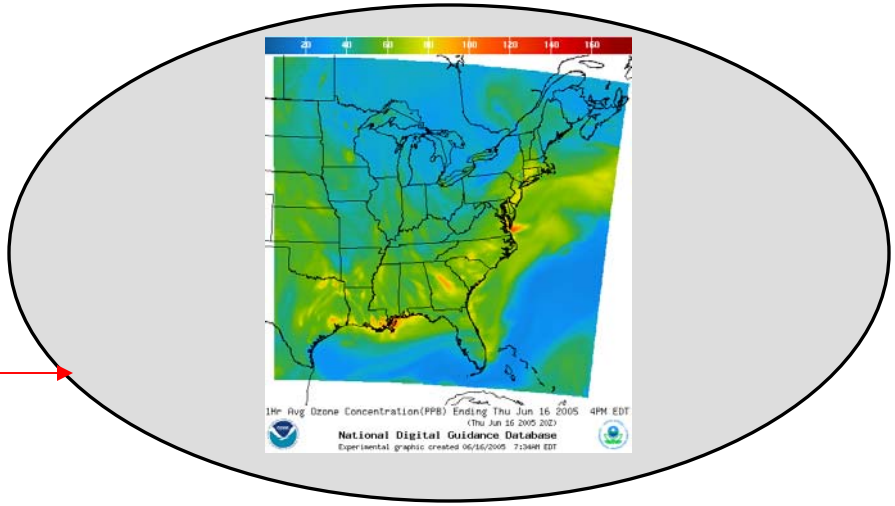
Developmental Testing

Does it work with operational systems?

Experimental Testing

Does it meet deployment readiness criteria?

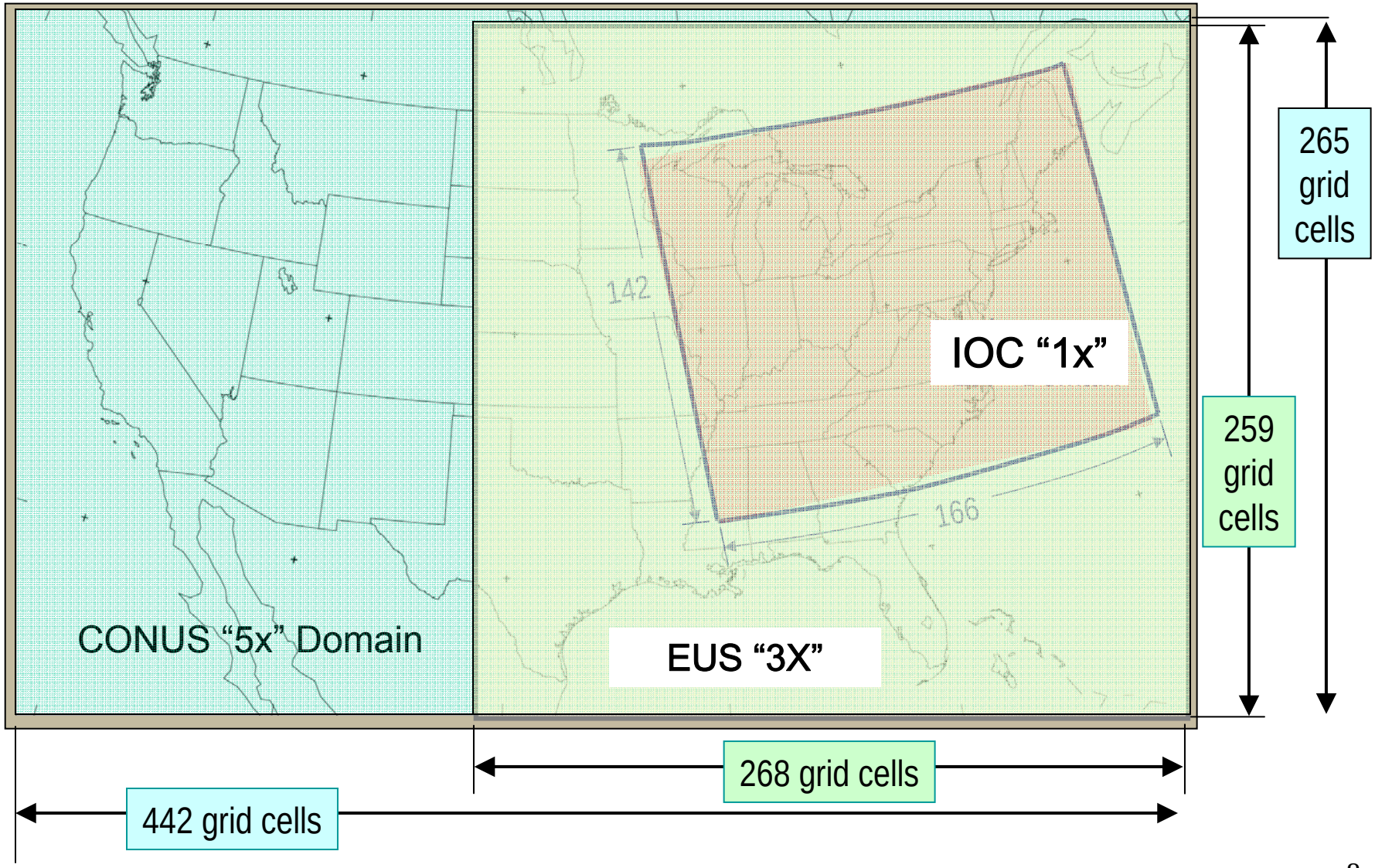
Deploy into Operations



Testing Domains: Summer 2005

Developmental: CONUS “5X”

Experimental: EUS “3x”



Expanding Domain, Ozone AQF Products:

Phased Development, Testing & Implementation, Summer 2005

	Features
Developmental (5x)	**Testing: more advanced vertical mixing;WRF/NMM when available**
Experimental (3x)	**Also Improved: AQ treatments of vertical mixing, cloud/radiation impacts, boundary conditions (ozone)**
Operational (IOC*; 1x)	**CMAQ-NAM. Improved: Eta-X in NAM, updated emissions data**

* Initial Operational Capability

Expanding the Initial Operating Capability:
Operational Readiness Criteria Summary

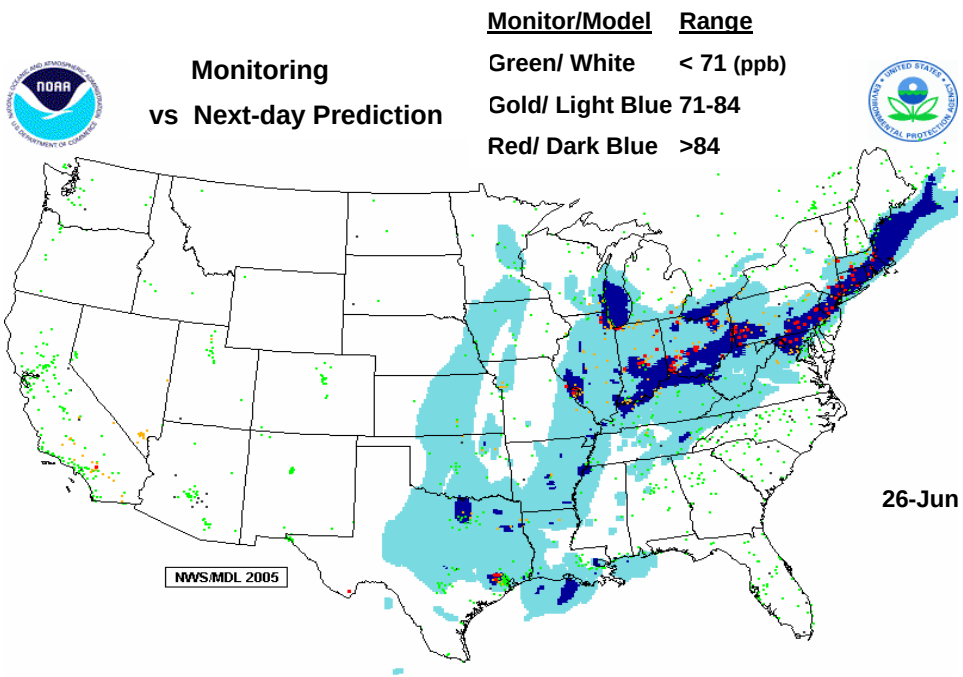
Criterion	Lead	Metric	Dates	Status
Objective Evaluation: Accuracy	*NCEP*	*> 90 %*	*6/1/05 – 8/1/05*	C
Subjective Feedback	*OCWWS*	*Positive on balance*	*6/1/05 – 8/1/05*	C
Production Readiness	*OCIO, NCEP*			C
On-time delivery		*> 95 %*	*6/1/05 – 8/1/05*	C
Back-up		*In place*	*6/1/05*	C
Data retention		*In place*	*6/1/05*	C
Near-real time verification	*NCEP*	*In place*	*6/1/05*	C
Final go/no go decision	*NWS*		*8/17/05*	C

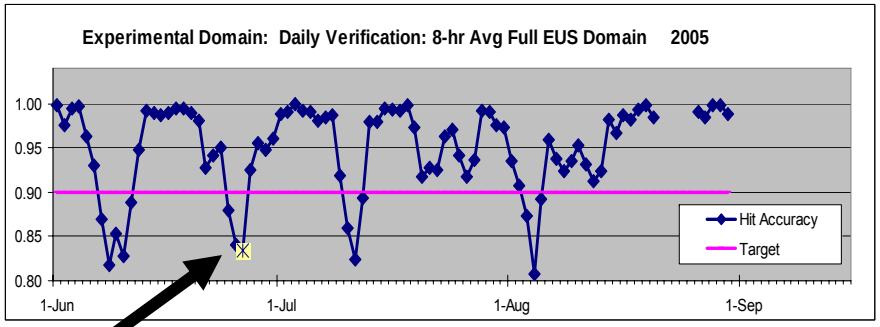
Key	Complete	On schedule	At risk	Remedial Action Required

Expanded Domain, Experimental Testing:

Example, Below-Target Accuracy

Daily maximum, Ozone 8-hr avg



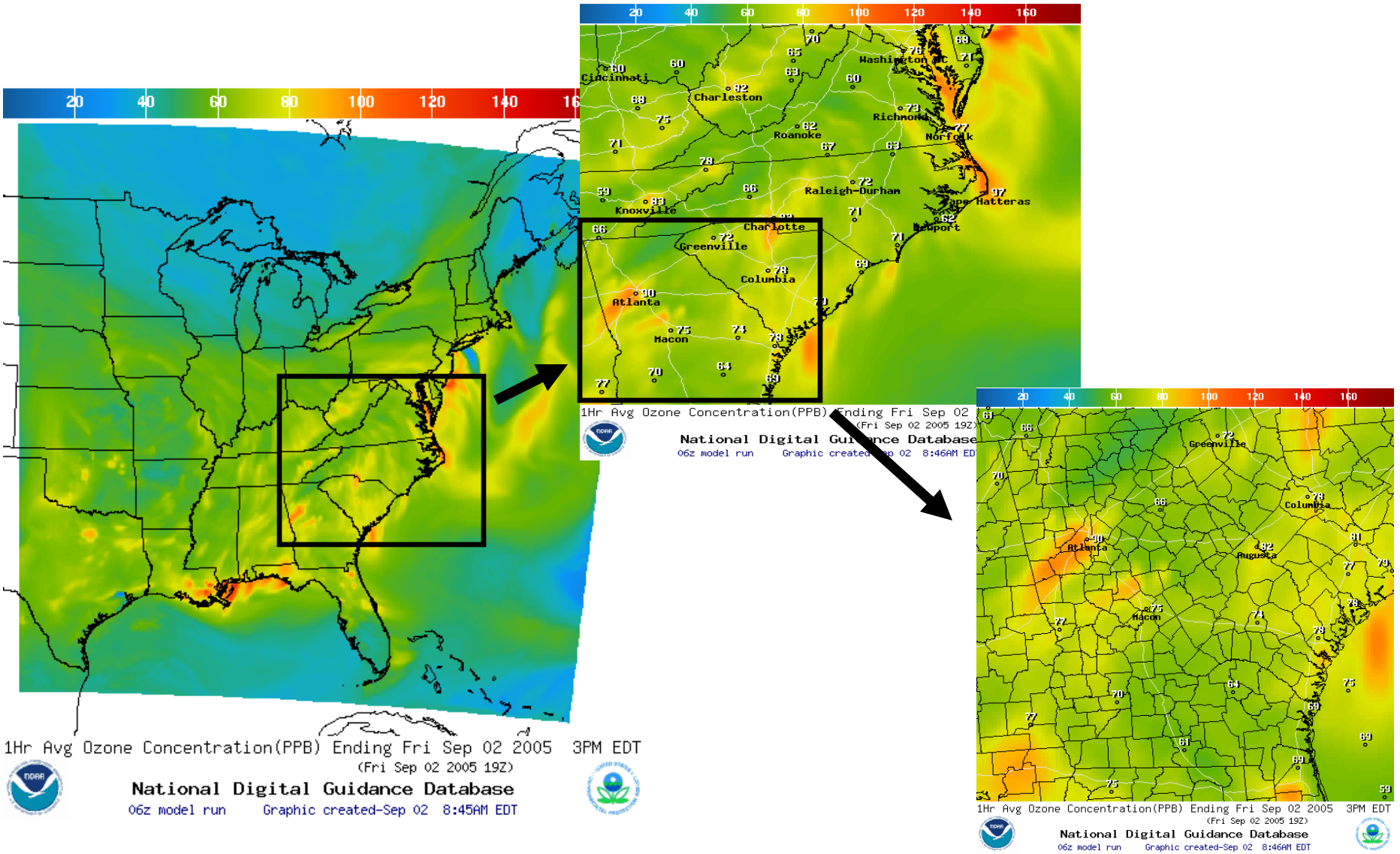


26-Jun 05

- Upgrades to reduce overprediction observed in developmental testing (2004) were incorporated in experimental (pre-deployment) testing from June, 2005
- In 2005, higher temperatures and early hurricanes are associated with more variable (and elevated) O_3. For comparable O_3, prediction accuracy generally improved relative to 2004.
- Cumulative accuracy (June – Aug): 95%; 9 days below target. Below-target days exhibit good pattern coverage

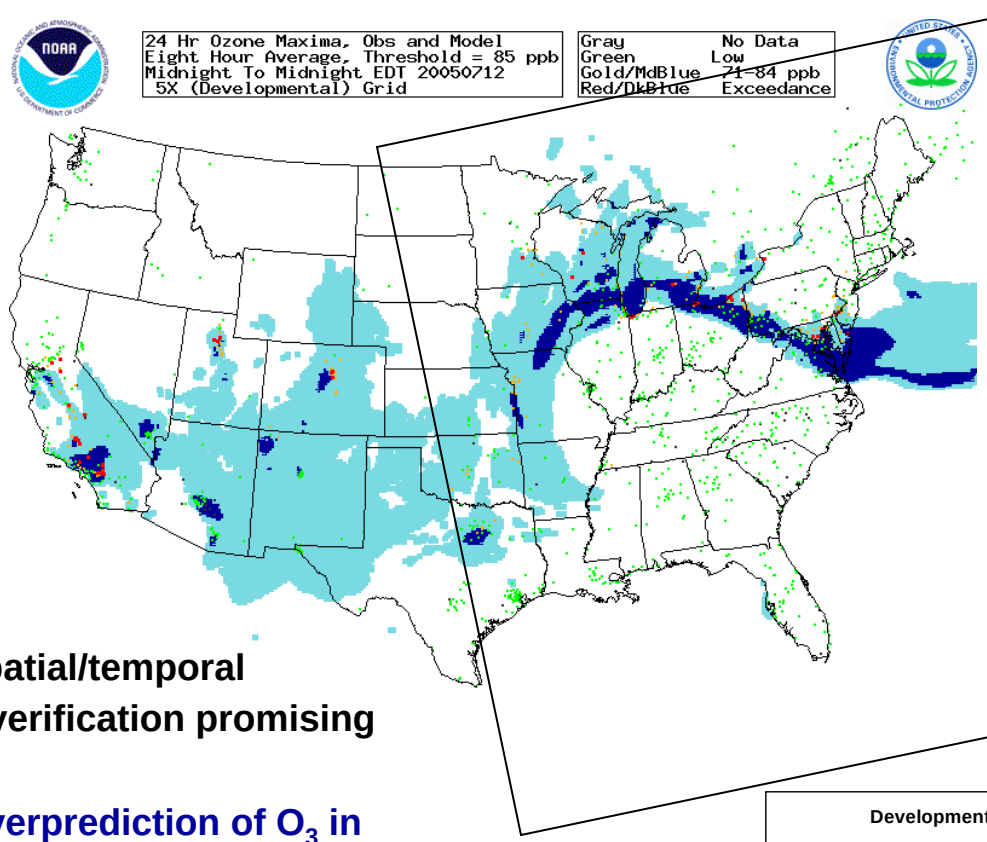
Sample AQ forecast guidance

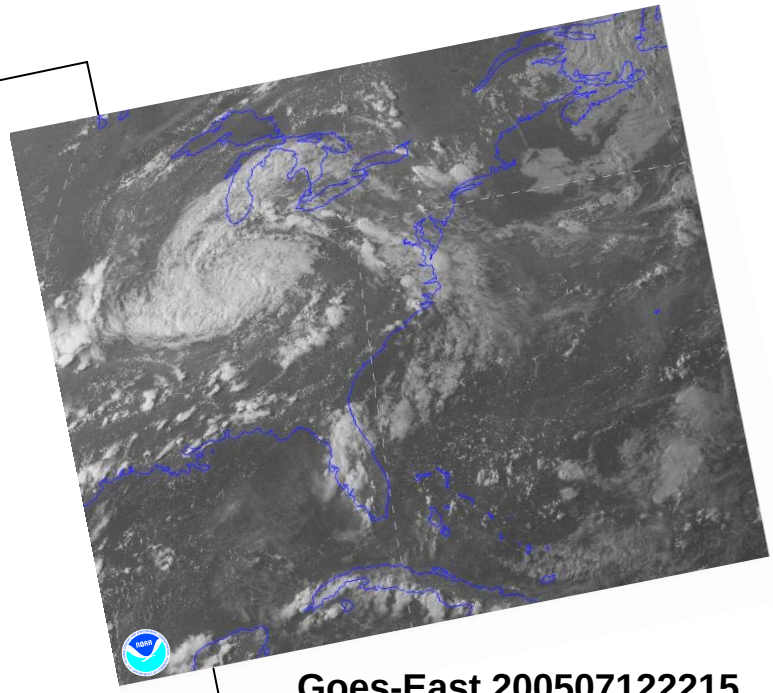
www.weather.gov/aq



CONUS 5X Domain Development & Testing

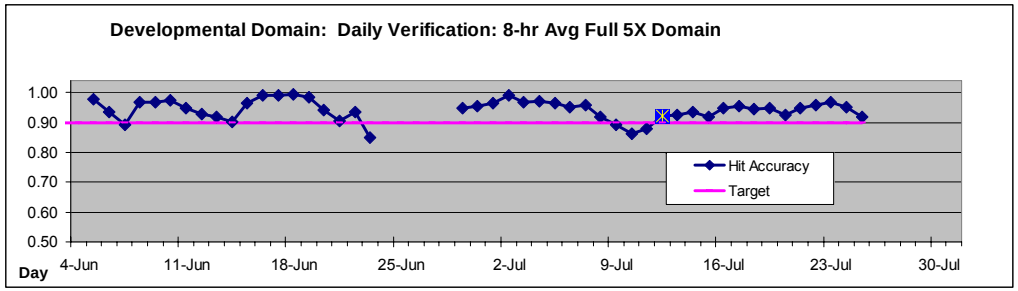
July 12 2005 Example: Hurricane Dennis





Goes-East 200507122215

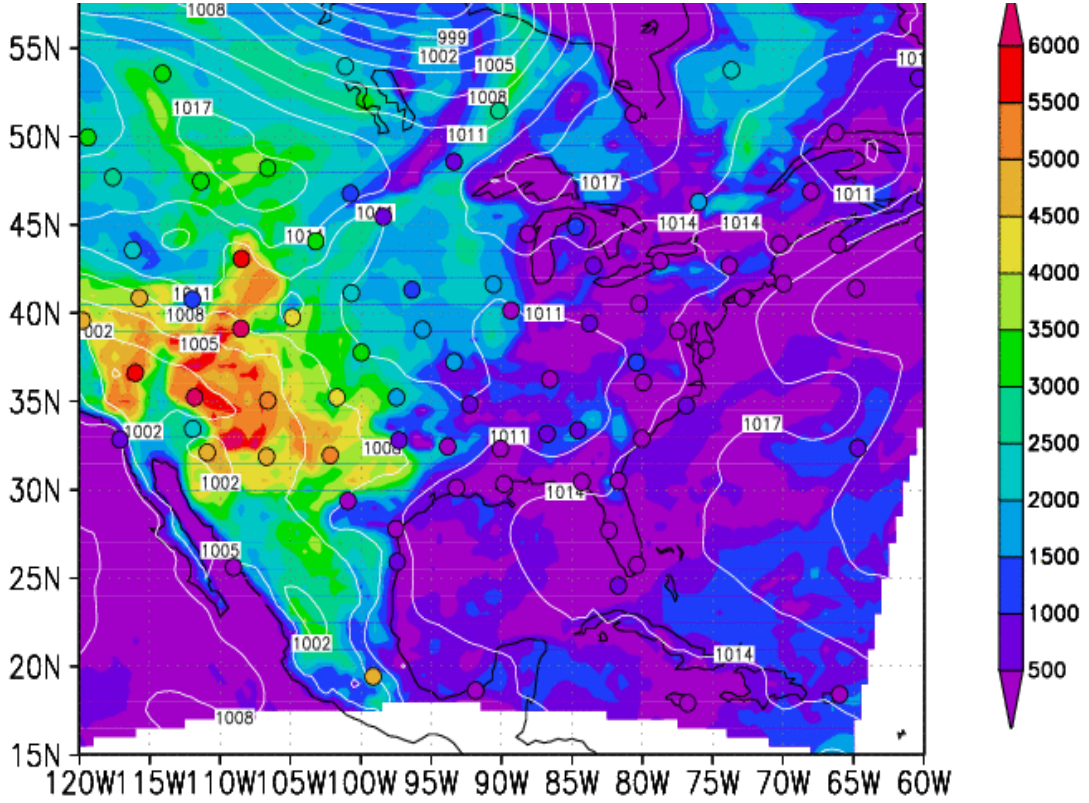
- **Spatial/temporal verification promising**
- **Overprediction of O_3 in elevated terrain (Rockies) & deep clouds**
- **Working on:**
  - ***linkage with WRF/NMM***
  - ***boundary conditions (lateral, upper)***
  - ***vertical mixing***



Verification of PBL Depth, Eta Prediction

July 15 2005: Very Deep over Southern Rockies

12-h Forecast of Eta PBL Heights vs 0Z Rawinsondes
July 15, 2005

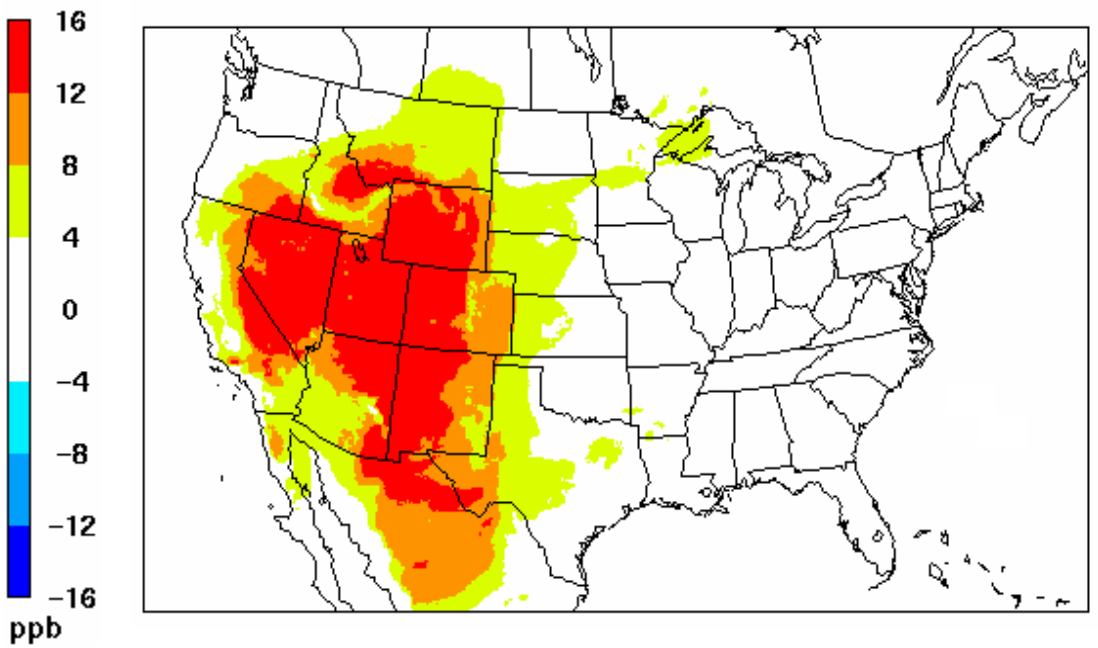


NCEP recently added PBL depth and cloud cover to routine verification package for mesoscale numerical weather prediction

Impact of Lateral Ozone Boundary Conditions on Predicted Ozone:

GFS-derived vs Default (static)

15 July 2005: Predicted O_3 Difference, GFS-derived - Static

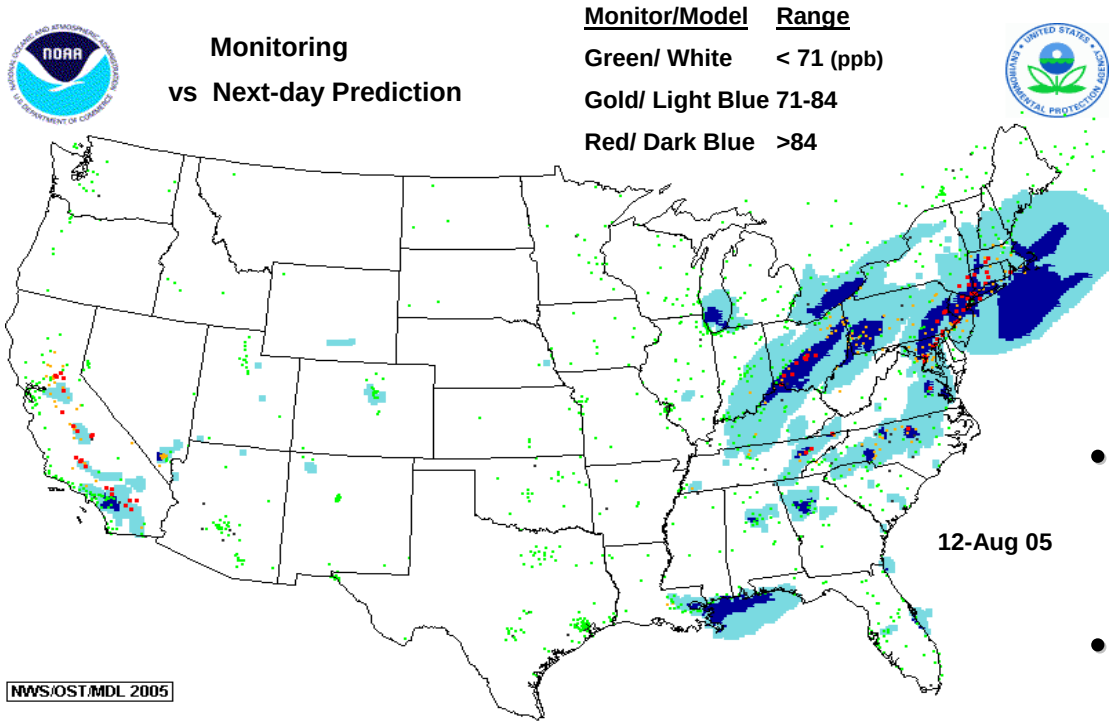


Static (reduced) values for O_3 upper lateral- boundary values reduce predicted ground-level O_3

Developmental Testing in 2005

Aug 12 Example: Improvement with Static LBC

Daily maximum, Ozone 8-hr avg



- **Static lateral boundary conditions (LBC) replace GFS- based ozone**
- **Overprediction reduced in elevated terrain (Rockies)**
- **Still Working on:**
  - *linkage with WRF/NMM*
  - *vertical mixing*

National Air Quality Forecast Capability

Plans for Smoke and Aerosol Guidance

Qualitative smoke capability:

- ***Development and experimental testing***
  - **late 2005, Spring 2006**
  - **CONUS domain; 1X per day**
  - **Use HYSPLIT configuration (12 km NAM)**
  - **Employ BlueSky Framework for emissions**
  - **Verification using NESDIS products**

- ***If testing successful, smoke guidance deployed operationally in Fall, 2006***

Aerosols predictions:

- ***Developmental testing over Eastern US***
- ***Expanding developmental testing to CONUS (summer 2006?)***

National Air Quality Forecast Capability

Status: December, 2005

Current Operational Capability:

- ***Eastern US, ground-level ozone***
- ***Hour-by-hour concentrations, 12km grid resolution, thru midnight next-day, updated twice daily***

Testing Expanded Capability:

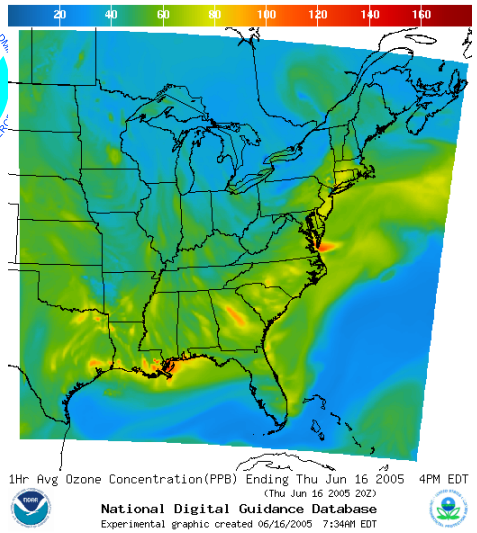
- ***CONUS, ozone: Developmental testing underway, focus on WRF conversion***
- ***Nationwide deployment, ozone: target FY09***
- ***Also testing aerosol components needed for particulate matter capabilities***

Major improvements incorporated:

- ***NAM-CMAQ linkage: T-profile; land-use.***
- ***Emissions updates: Mobile 6; extrapolations to current year emissions***
- ***Improvements in PBL, cloud treatment (ongoing), radiation flux***

Appendix

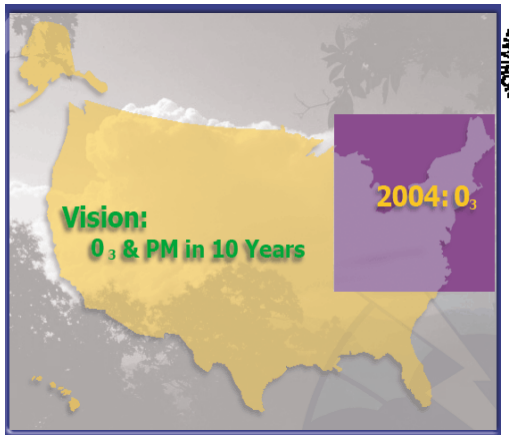
- Fact Sheet on AQ Forecasting
- Summary of 2005 Model upgrades
- More detail, 2005 Operational Readiness Criteria: Comparison of IOC and Expanded-Domain Predictions
- Example: Further Evaluation Statistics
- Future Science Infusion



National Air Quality Forecast Capability:

Improving the Basis for AQ Alerts

AQ Information for People at Risk



	Current AQ Alerts	***NWS Operational Capability***		
		Current (9/05)	Next (2008)	**10-Year** Vision
Purpose: Limit adverse effects from poor AQ, by providing:	Next-day warnings for large cities	State-of-the-science ozone forecast guidance	State-of-the-science ozone forecast guidance	State-of-the-science ozone and particulate matter forecast guidance
Products for Public	Daily AQ alerts; predicted interpretive AQ Index category	Hour-by-hour predictions of air pollutant concentrations in digital & graphical formats	Hour-by-hour predictions of air pollutant concentrations in digital & graphical formats	Hour-by-hour predictions of air pollutant concentrations in state-of-the-art formats
Coverage	Approx 300 cities	Eastern United States	Nationwide	Nationwide
Pollutants Forecasted	AQ Index for ozone; some cities include particulate matter	Ground-level ozone	Ground-level ozone	Ground level ozone, particulate matter, possibly others
Forecast Period	Next-day; also through weekends	Forecast guidance through midnight next day	Forecast guidance through midnight next day	Forecast guidance extended to 2 days or beyond
Spatial Resolution	Alerts are community-wide; little/ no other spatial information	12 kilometer grid	5 km grid	2.5 kilometer grid
Temporal Resolution	Daily	1-hr and 8-hr averages each hour		

Expanding the IOC: 2005 Improvements

Ozone testing:	3X Now Operational ! (NAM NWP with Eta)	Developmental (NAM moving to WRF)
Grid coordinates	interpolate to CMAQ C-grid and CMAQ σ	In 2006: common E grid; common σ-P for NAM & CMAQ
Upgrades to Eta	1 km NOAH landuse	
	2 mb top; improved precipitation assimilation	
Improved emissions	2005 Updates to mobile and EGU sources	
Photolysis	surface radiative flux scaling	surface and 3-D radiative flux; photolysis rates based on NAM radiation fields
PBL\	PBL height	Incorporate TKE/Kh
Clouds		
Phases	water	water, graupel & ice
Mixing	Limit chemical mixing from above clouds	Testing ACM
Lateral BC (ozone)	GFS above 6 km; static below	more vertical resolution near tropopause

Objective Verification (NCEP)

Criterion	Metric	Dates	Status
Objective Evaluation: Accuracy	Correctly predict exceedance and non-exceedance of ozone concentration threshold metrics, during the 24-h valid forecast period, on 90% or more days Threshold metrics: 1-hr avg > 124 ppb 8-hr avg > 84 ppb	6/1/05 – 8/1/05	C

Summary Performance: June 1- July 26, 2005

- Exceeds target (1-hr)

8-hr: 34/39 days following 6/9 correction

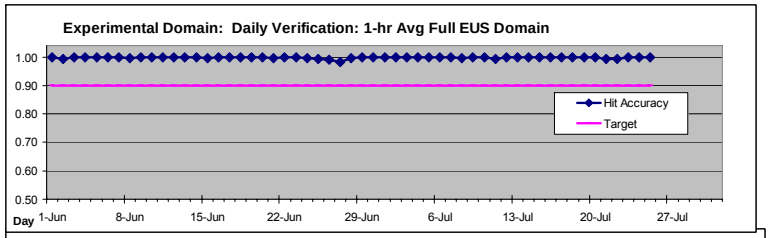
cumulative accuracy (92%)

- Over NEUS, Expanded Guidance

Comparable to IOC

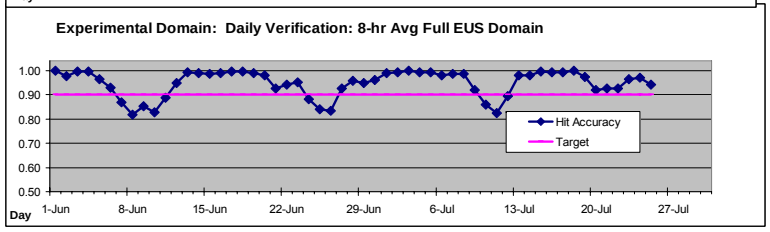
Full EUS

1-hr avg



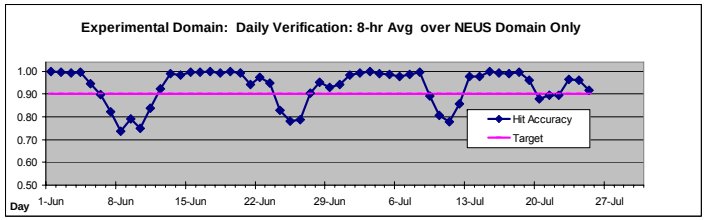
Full EUS

8-hr avg



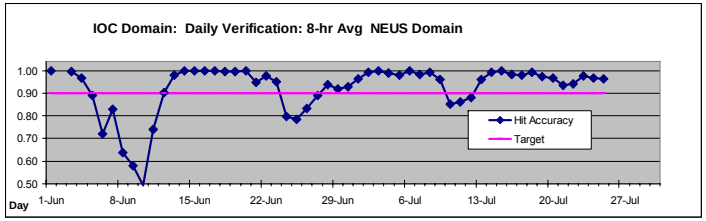
Expt Domain: NEUS only

8-hr avg

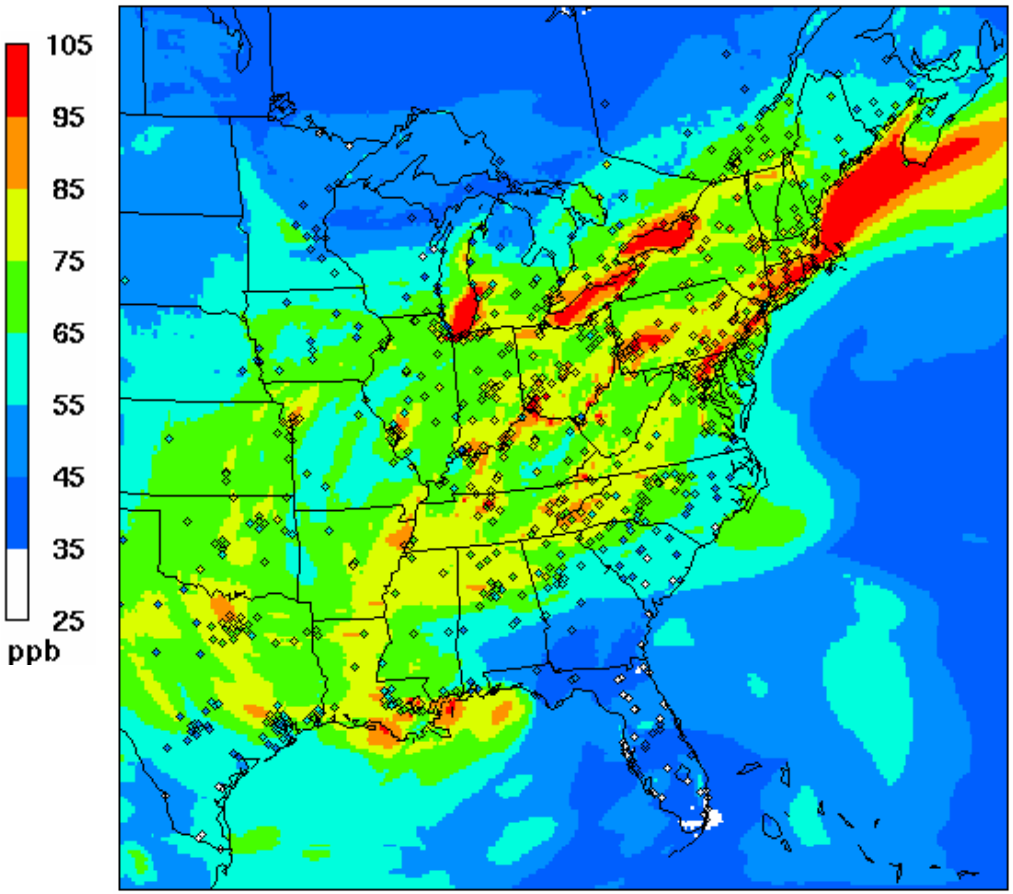


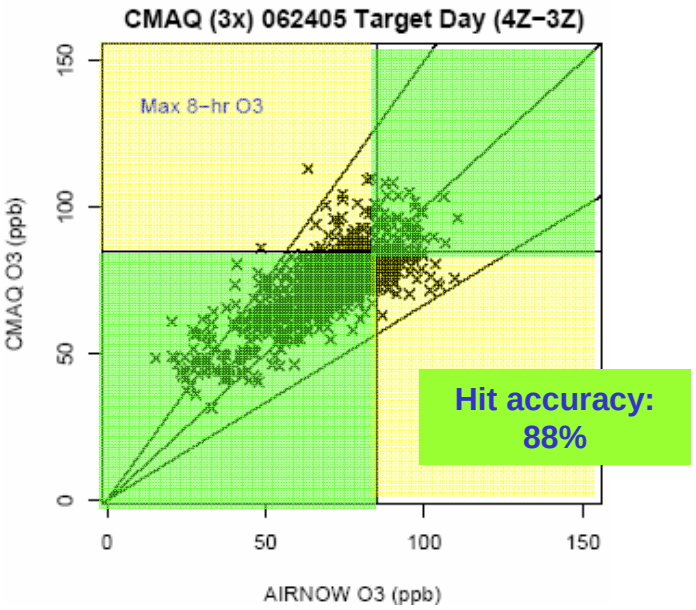
IOC (NEUS):

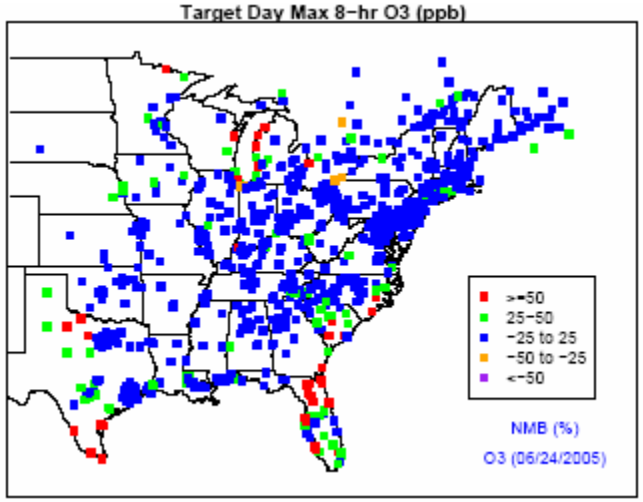
8-hr avg



Verification Statistics, June 24, 2005: Below-Target Example







Obs. Mean	*Model Mean*	*RMSE*	*NME*	*MB*	*NMB*	*R*
68.43	***73.02***	***11.66***	***13.12***	***4.59***	***6.71***	***0.76***

Future Science Infusion

NOAA planning for the expansion of the AQ forecast capability to

- National coverage of ozone predictions
- Addition of particulates forecast guidance
- Extended forecast range

Continuing R&D required

- OAR and EPA working actively with NWS to provide prototype capabilities for pre-operational development, testing experimental production, and implementation:
  - ***e.g. June 2005 chemical data assimilation workshop***

Assuring quality with science peer reviews:

- Design review of major system upgrades (initial, and yearly upgrades)
- Diagnostic evaluations with field campaigns and evaluations
- Publication of T&E in peer-reviewed literature
  - ***(Otte et al., Weather and Forecasting, June 2005)***